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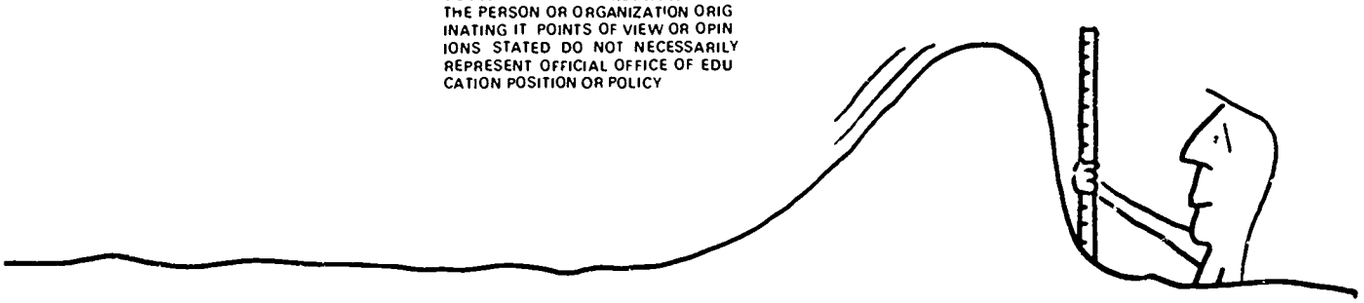
ABSTRACT

This programmed instruction booklet is an interim version of instructional materials being developed by Harvard Project Physics. It is the first of two booklets on the topic of waves and covers pulses, how pulses travel, and what happens when two pulses pass through the same region at the same time. For the second booklet in this series, see SE 015 553. (DT)

Project Physics **Programmed Instruction**

Waves 1



Authorized Interim Version [redacted] 1968-69

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INTRODUCTION

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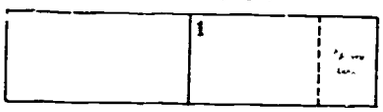
Waves 1 The Superposition Principle

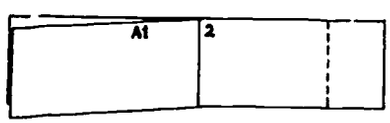
Knowledge of the behavior of waves is of basic importance in physics. In this program you will learn something about brief wave disturbances—pulses: how they travel, and what happens when two pulses pass through the same region at the same time.

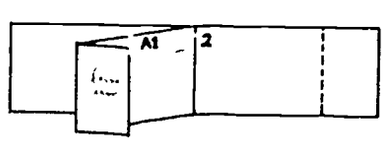
INSTRUCTIONS

1. Frames: Each frame contains a question. Answer the question by writing in the blank space next to the frame. Frames are numbered 1, 2, 3, ...

2. Answer Blocks: To find an answer to a frame, turn the page. Answer blocks are numbered A1, A2, A3, ... This booklet is designed so that you can compare your answer with the given answer by folding back the page, like this:







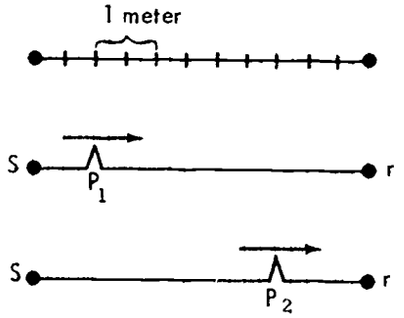
3. Always write your answer before you look at the given answer.

4. If you get the right answers to the sample questions, you do not have to complete the program.

Sample Question A

The disturbance travels from P_1 to P_2 in a time Δt.

If $\Delta t = 1.0$ seconds, what is the speed at which the disturbance travels?



Answer to A

$$v = \frac{\Delta d}{\Delta t}$$

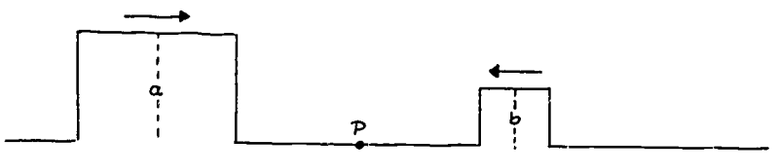
$\Delta d = 3.0$ m

$\Delta t = 1.0$ sec

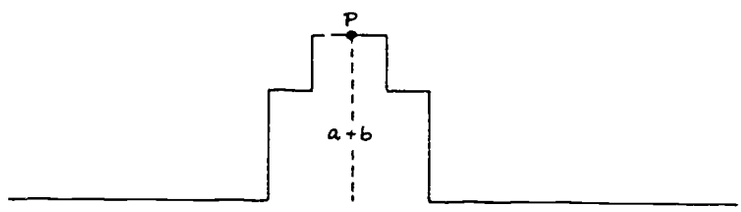
$$v = \frac{3.0 \text{ m}}{1.0 \text{ sec}} = 3.0 \text{ m/sec}$$

Sample Question B

The diagram shows two pulses traveling towards each other along a rope. An instant later the pulses arrive at the center of the rope — what is the maximum displacement of the rope at that instant ?



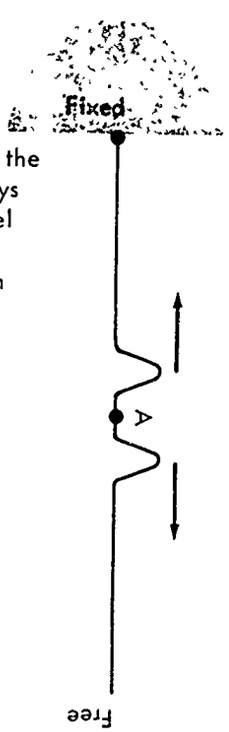
Answer to B



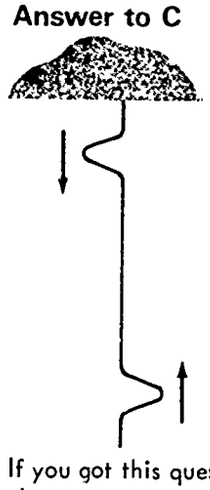
Maximum displacement is a + b.
If you missed this, you can profit by working through this program booklet—begin with question 1.
If you got Sample Question B right, go on to Sample Question C.

Sample Question C

A rope is hung as in the diagram, one end fixed and the other end free. At point A the rope is moved sideways and back suddenly, creating similar pulses that travel towards the ends.
Sketch what the pulses will look like after reflection from the ends.



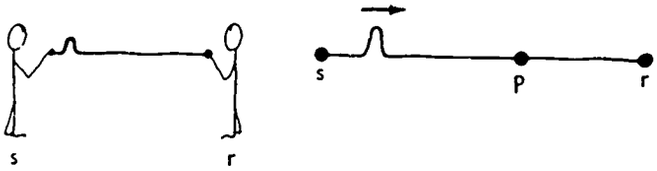
Answer to C



If you got this question right also, you need not complete Waves I.
If you missed Sample Question C (but got B right) begin this program at question 16.

1

Two people hold opposite ends of a rope. The sender, s, snaps his end of the rope, creating a disturbance that travels along the rope toward the receiver, r.



A short time (Δt) later, the disturbance passes point P.

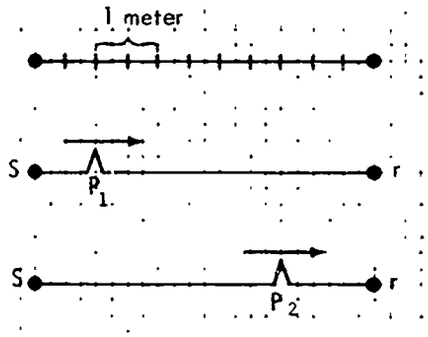
Draw the disturbance as it passes P.

A1

2

The disturbance travels from P_1 to P_2 in a time Δt.

If $\Delta t = 1.0$ seconds, what is the speed at which the disturbance travels in the rope?



A2

$$v = \frac{\Delta d}{\Delta t}$$

$\Delta d = 3.0$ m

$\Delta t = 1.0$ sec.

$$v = \frac{3.0 \text{ m}}{1.0 \text{ sec}} = 3.0 \text{ m/sec}$$

3

A brief disturbance that moves through a medium is called a pulse.

In the case of the previous two frames, the medium is (i) _____, and the source of the pulse is (ii) _____.

A3

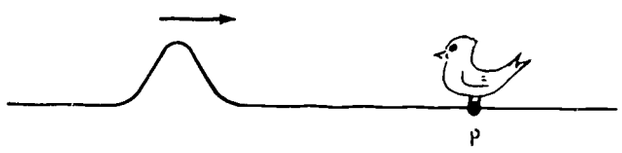
(i) the rope

(ii) the hand movement of the 'sender'.

4

A small object is fastened to the rope.

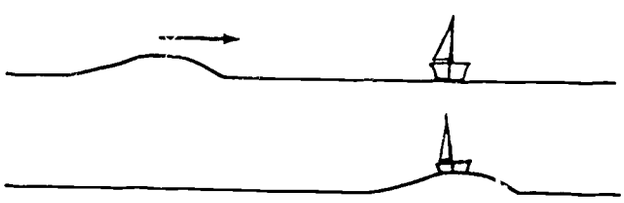
Draw the object and pulse when the pulse is centered at point P.



A4

5

We know that the water wave contains energy because _____.



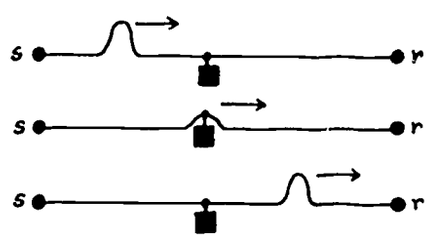
A5

For one thing, the wave lifts the boat.

6

If you lift a weight against gravity, you do work, and to do work requires energy.

A pulse passes a small weight attached to the rope.



From this experiment it can be seen that the pulse transmits _____, because it lifted the weight as it passed.

A6

energy

7

A pulse is a disturbance moving through

(i)_____, and

transmitting (ii)_____.

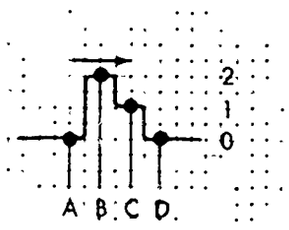
A7

(i) a medium
(ii) energy

8

A disturbance can be described as a displacement of particles in a medium from their normal positions.

Complete the table.



Displacement	0			
Point	A	B	C	D

A8

Displacement	0	2	1	0
Point	A	B	C	D

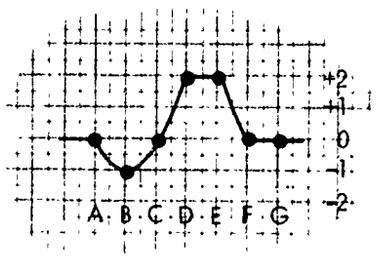
9

Draw a possible pulse that has the following displacements:

Displacement	0	-1	0	+2	+2	0	0
At Point	A	B	C	D	E	F	G

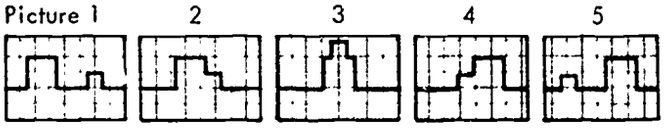
A9

one possibility:



10

Two pulses are shaken onto the rope from opposite ends, and the pulses pass at mid-rope. A movie camera shows the interaction of the two pulses.



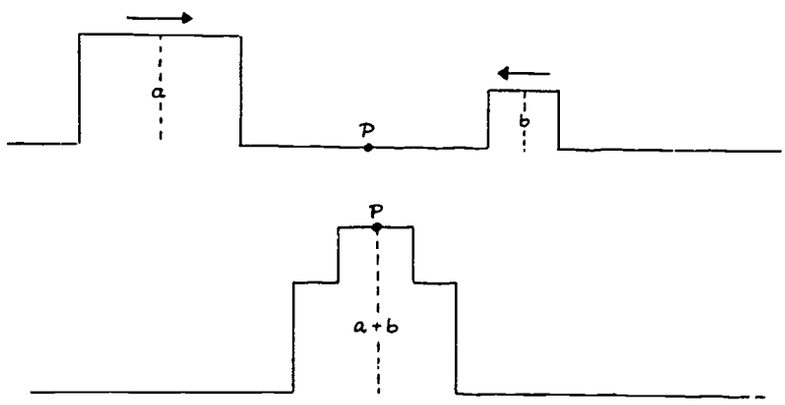
Has there been any change in the shape of the pulses as a result of the interaction?

A10

no

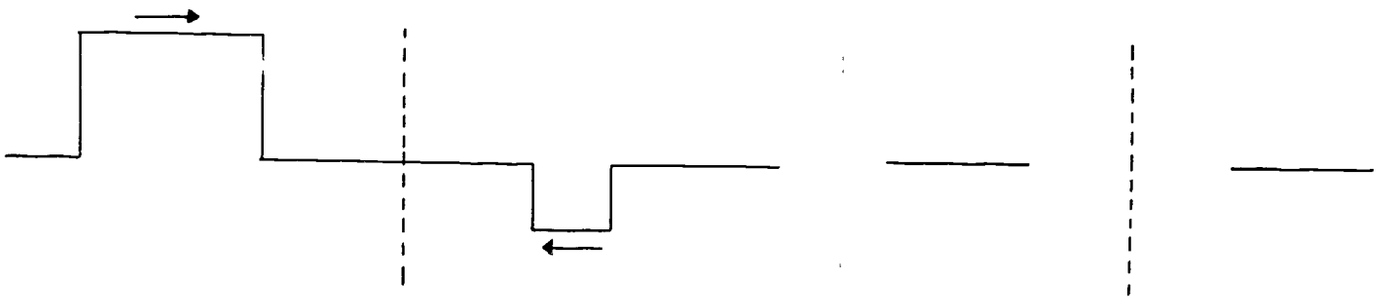
11

When two waves pass through the same region of a medium, the displacement of each point is the sum of the displacements that each wave would cause by itself. For example , as two pulses of displacements a and b pass a point P on a rope, the displacement of point P will be a + b :

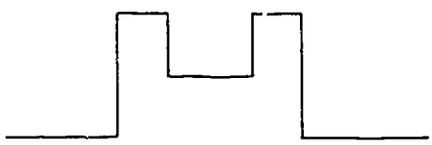


12

Sketch what the displacement of the rope will be as the two pulses arrive at the center of the rope:

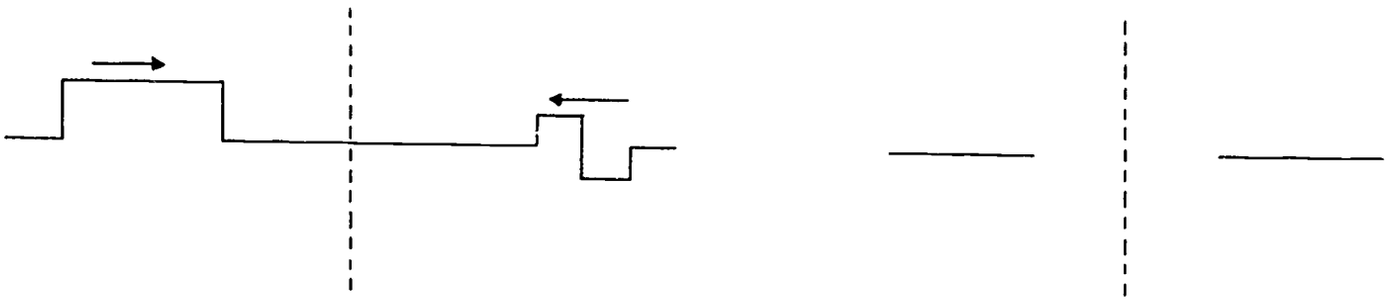


A12

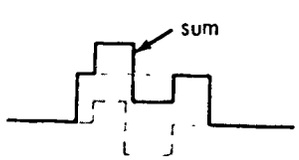


13

Sketch what the displacement of the rope will be as the two pulses arrive at the center of the rope.

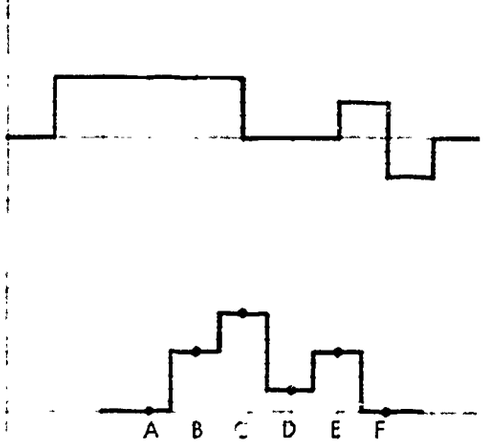


A13



14

The two pulses in the top diagram are shown superposed in the lower diagram. Complete the displacement table for the labeled points.

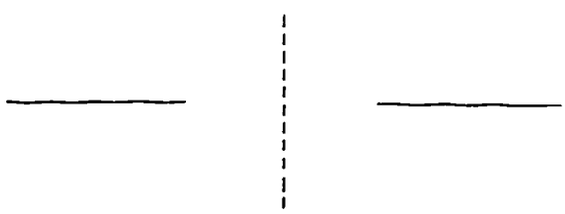


Displacement						
Point	A	B	C	D	E	F

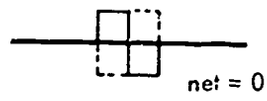
Displacement	0	5	8	2	5	0
Point	A	B	C	D	E	F

15

Complete the drawings, showing superposition of the two pulses when the pulse centers coincide.



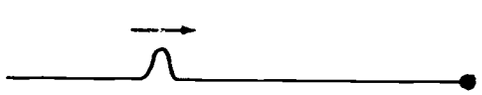
A15



At the exact moment they cross the center the displacement is zero.

16

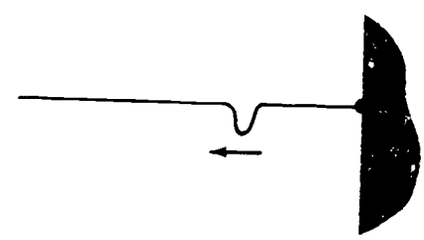
A pulse on a rope approaches a point that is attached to a wall.



Experiments show that the wave does not continue past the fixed point, but is reflected back in the opposite direction, and the pulse appears on the opposite side of the rope.

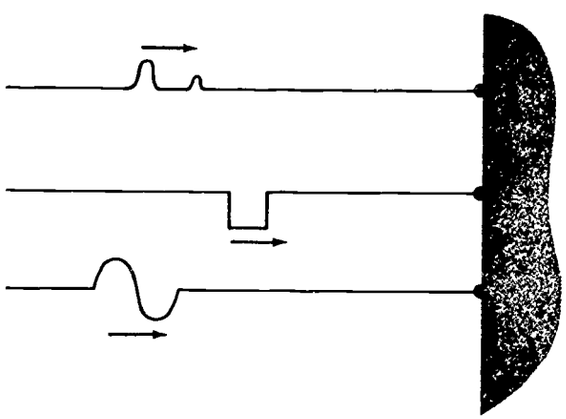
Draw the pulse after reflection.

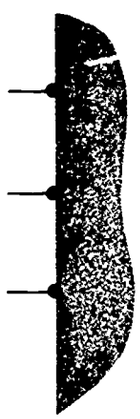
A16



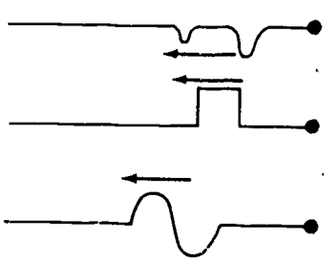
17

Draw the pulses after reflection.





A17



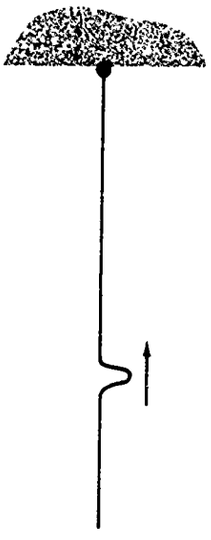
18

A rope is suspended in a stairwell, and a pulse is shaken on the rope from the top.

Experiments show that the wave is reflected from the free end but on the same side of the rope.

Draw the pulse after reflection.

A18



19

A rope is hung as in the diagram, one end fixed and the other end free. At point A the rope is moved sideways and back suddenly, creating similar pulses that travel towards the ends.
Sketch what the pulses will look like after reflection from the ends.

A19